Argonne NATIONAL LABORATORY

Transportation Research and Analysis Computing Center

TRACC

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In cooperation with the U.S. Department of Transportation,
Northern Illinois University and the University of Illinois

U.S. DEPARTMENT OF ENERGY

Argonne National Laboratory

Situated on 1,500 beautiful, wooded acres and surrounded by the Waterfall Glen Forest Preserve, Argonne National Laboratory is one of the nation's leading federally funded research and development centers.

- Argonne National Laboratory is one of the U.S. Department of Energy's oldest and largest national laboratories for science and engineering research.
- Since 1990, Argonne has worked with more than 600 companies and numerous federal agencies and other organizations.
- Argonne's mission is to apply a unique mix of world-class science, engineering and user facilities to deliver innovative research and technologies and actively seek opportunities to work with industry to transfer our technologies to the marketplace through licensing, joint research and many other collaborative relationships.
- Research at Argonne centers around the principal areas of Energy, Biological and Environmental Systems, and National Security
- Argonne is managed by UChicago Argonne, LLC, for the U.S. Department of Energy's Office of Science and is located in southwest DuPage County, IL, 25 miles (40 km) southwest of Chicago.

TRACC – A National User Facility to Meet USDOT Advanced Computation Needs

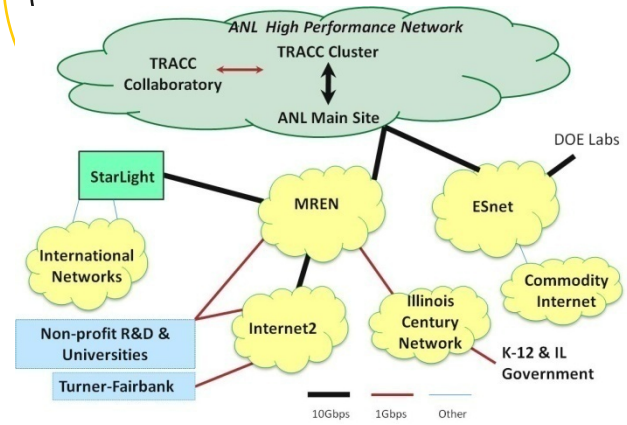
- USDOT and USDOE transportation research programs, private industry, and state and regional transportation agencies are moving to simulation-based design and analysis for improvements in efficiency, economics, and safety
- Higher fidelity analysis in areas such as crashworthiness, aerodynamics, combustion, thermal management, weather modeling, and traffic simulation require access to state-of-the-art computational and visualization facilities
- Argonne expertise in high-performance computing and transportation system analysis provides the basis for a national HPC user facility and a focal point for computational research for transportation applications

TRACC - High-Performance Computing for Transportation Research and Applied Technology

TRACC Is a National USDOT Supercomputing Facility

TRACC High Performance Compute Cluster

- 1024 cores /128 compute nodes
- 180TB Global Parallel File System Disk Storage
- 160TB Archive/Backup Tape Storage



High-bandwidth connectivity is provided via the Argonne high-performance network to world-wide research and education networks (Internet2 and ESnet)

TRACC Collaboratory - Visualization, Access Grid, and Digital Conferencing

Partner Organizations Add Expertise & Infrastructure

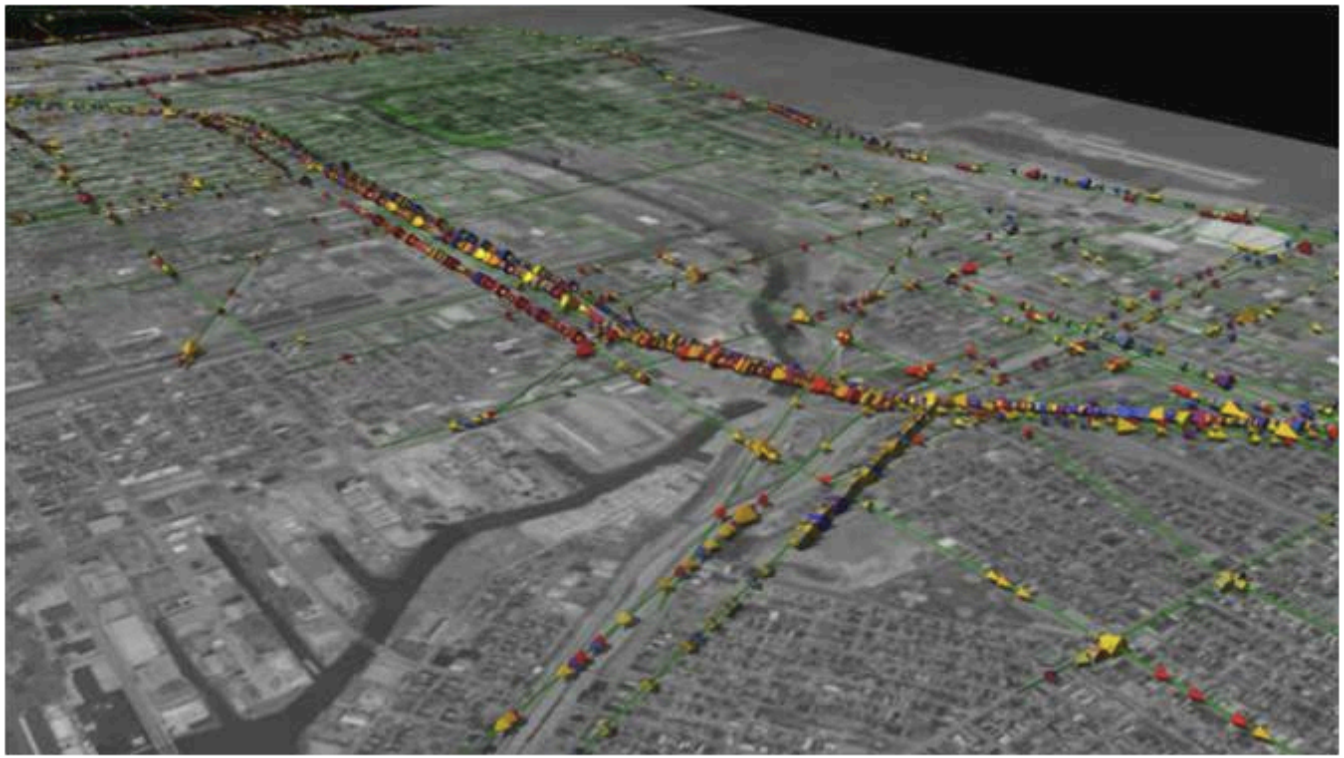
- Northern Illinois University (NIU)
  - Computational Fluid Dynamics for bridge hydraulics
  - Computational Structural Mechanics for bridge vibration analysis
  - Traffic simulation & evacuation planning
- University of Illinois (UIUC)
  - Visualization for traffic analysis
  - Loaned equipment & infrastructure for advanced visualization

- DuPage Airport Authority (DAA)
  - Offices & Collaboratory
- DuPage National Technology Park (DNTP)
  - TRACC Cluster Operations

Current USDOT Application Focus Areas

- **Traffic Modeling and Simulation and Emergency Transportation Planning**
  - Chicago Metropolitan Area model using multi-modal simulation techniques
  - Collaboration with the Chicago Metropolitan Agency for Planning, IDOT, FHWA and Northern Illinois University
- **Multidimensional Data Visualization**
  - Visualization of transportation system modeling from USDOT TRANSIMS modeling system with UIUC National Center for Supercomputing Applications
- **Computational Fluid Dynamics for Infrastructure Analysis**
  - Bridge hydraulics, including flooding and scour, and roadside hardware aerodynamics using computational fluid dynamics (CFD)
- **Computational Structural Mechanics for Transportation Applications**
  - Vehicle crash analysis, roadside barrier impact, accident reconstruction and occupant response
  - Bridge dynamic response due to traffic loading, stay-cable response due to traffic loading and wind loading, stability of bridges with piers in scour holes, including fluid-structure interaction

Traffic Modeling and Simulation and Emergency Transportation Planning



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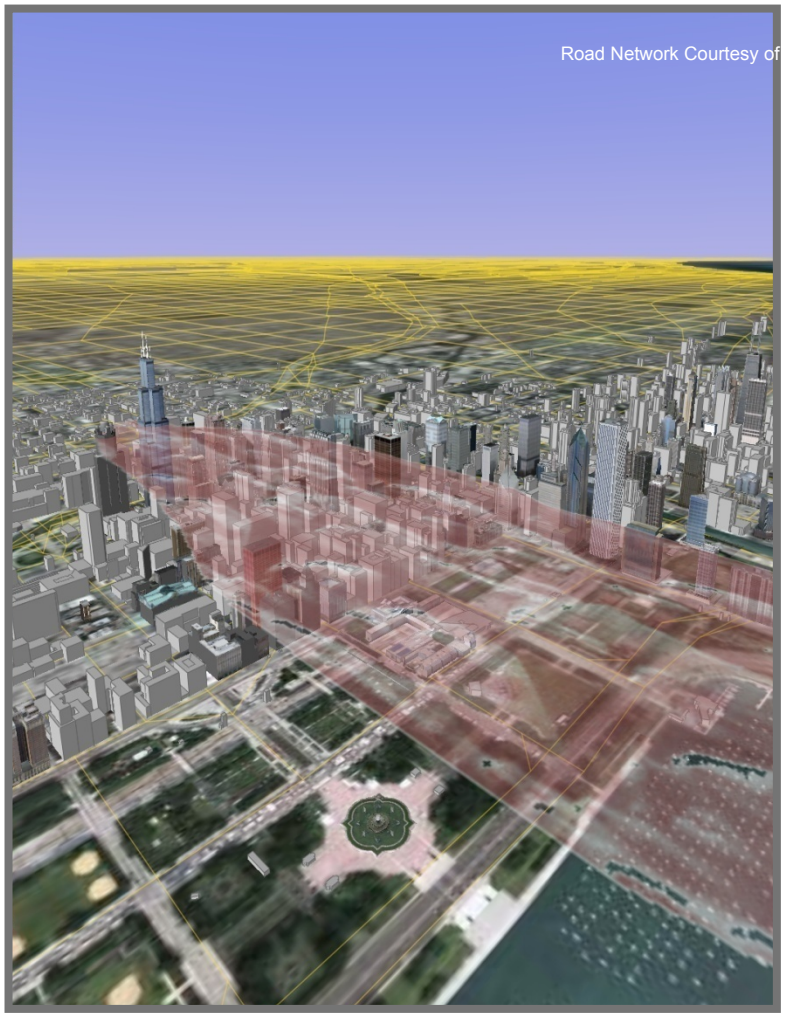
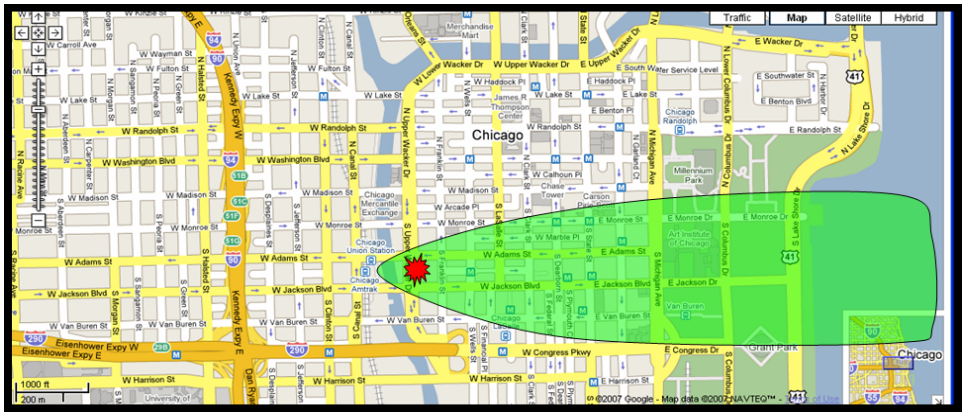
TRANSIMS Application Development

- Development of the Chicago Metropolitan Area (CMA) TRANSIMS model and road network
- Detailed road network in collaboration with Chicago Metropolitan Agency for Planning (CMAP)
- Software Development – User Interface and Visualization
  - TRANSIMS Studio
  - TransimsVIS
  - Metropolis
- User Support and Training
  - TRACC Cluster
  - TRANSIMS applications

Emergency Evacuations of Chicago Business District

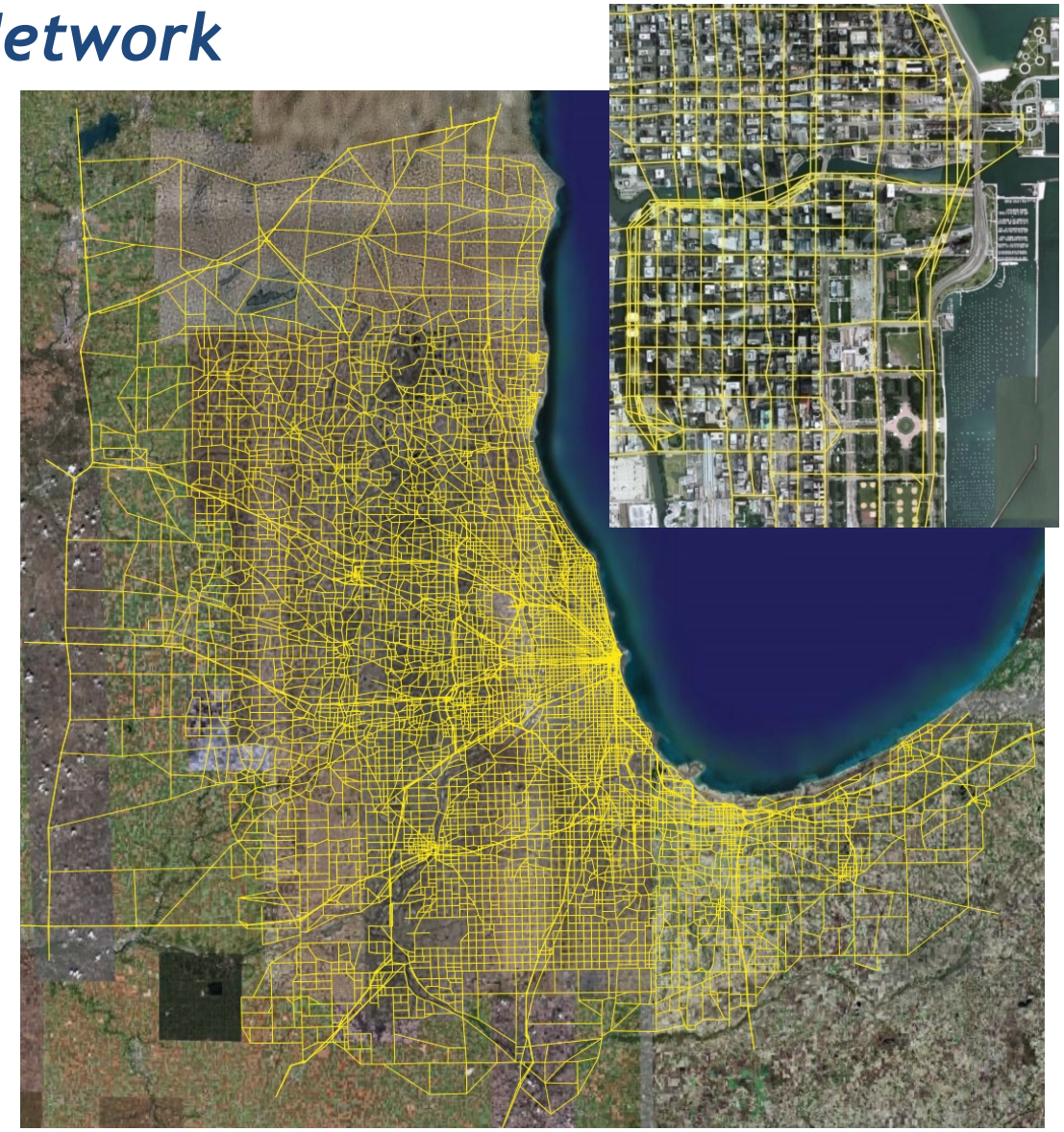
- This project has been implemented to model the effects of a no-notice event on the multi-modal regional transportation system in the Chicago metropolitan area
- The chosen scenario postulates a radioactive release following an explosion at the base of the Sears Tower
- This project deals with the dynamic effect on the transportation system



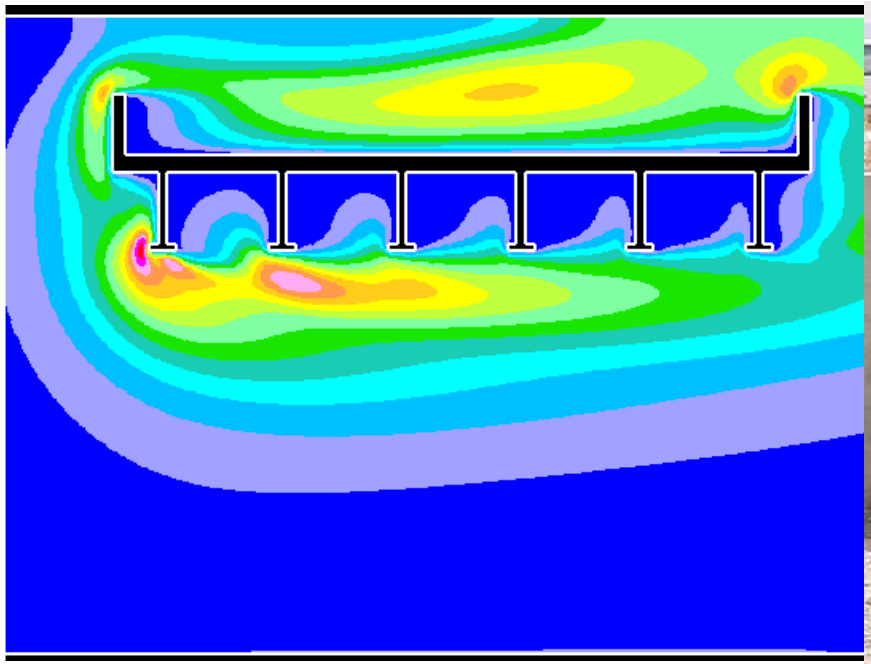


The Regional Road Network

- ~10,000 square miles
- Road network
  - 40,000 links
  - 14,000 intersections
  - 110,000 locations
- ~26.5 million vehicle trips
- ~1.5 million transit trips
- Trip tables
  - Break-down by purpose (work, truck, airport, and many more)



Bridge Hydraulics and Computational Fluid Mechanics



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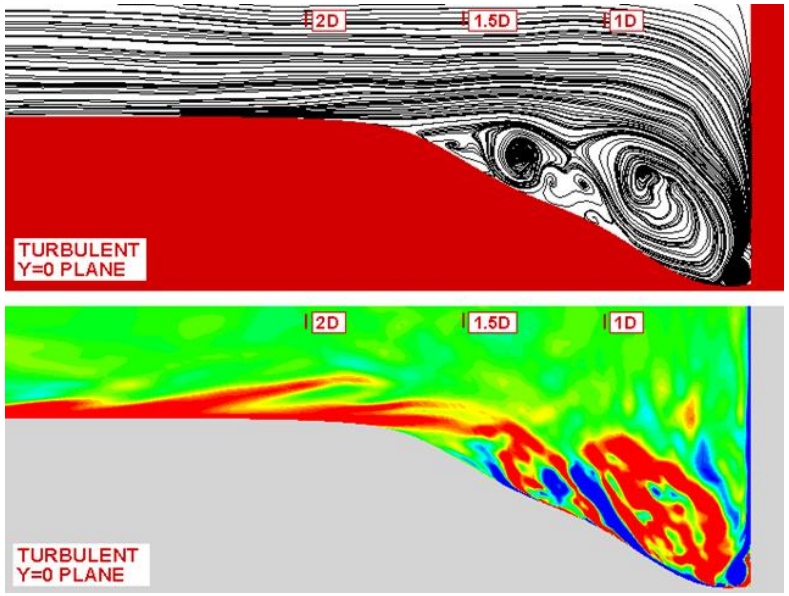
Current CFD Collaborative and User Projects

- Hydraulic Forces on Bridge Structures and Scour in Floods
  - FHWA Turner Fairbank Highway Research Center (TFHRC)
  - University of Nebraska
  - Northern Illinois University
  - Argonne National Laboratory
- Investigation of Bridge Pier and Abutment Scour Using Large Eddy Simulation (LES)
  - University of Iowa



Flow in a scour hole in front of a pier

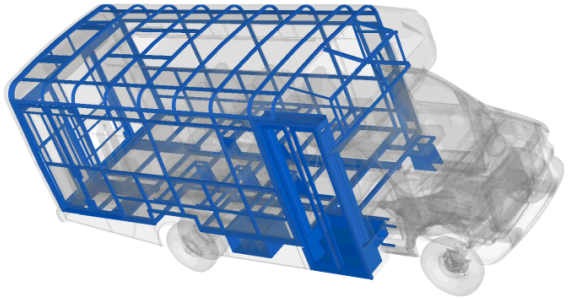
- Wind Loads on Highway Sign and Traffic Signal Structures
  - University of Iowa
- LES Analysis of Turbulent Flow Over Beds of Packed Spheres (New)
  - University of Illinois Champaign-Urbana
  - Argonne National Laboratory
- Fish Passage through Culverts (New)
  - TFHRC, Argonne National Laboratory, University of Nebraska

CFD Software on the TRACC Cluster

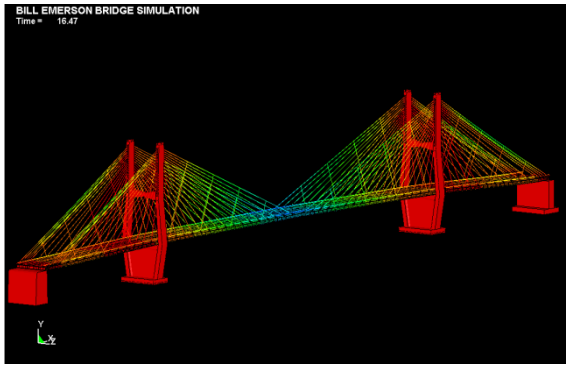
- CD-adapco – unlimited license
  - STAR-CD
  - STAR-CCM+
  - STAR-DESIGN
- ANSYS – 4 seat 32 core license
  - FLUENT
  - GAMBIT
- Flow Science – University of Nebraska evaluation
  - FLOW-3D
- University of Iowa Large Eddy Simulation (LES)

  (3) codes ported to TRACC
  - TRACC provides technical assistance for custom software

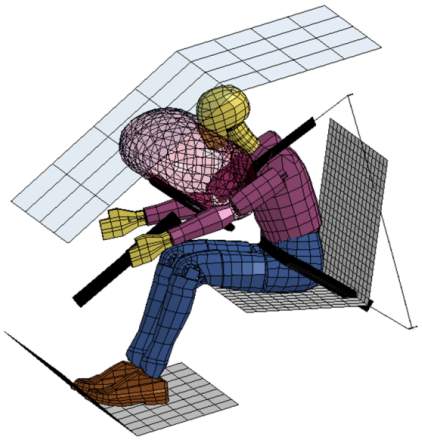
Computational Structural Mechanics



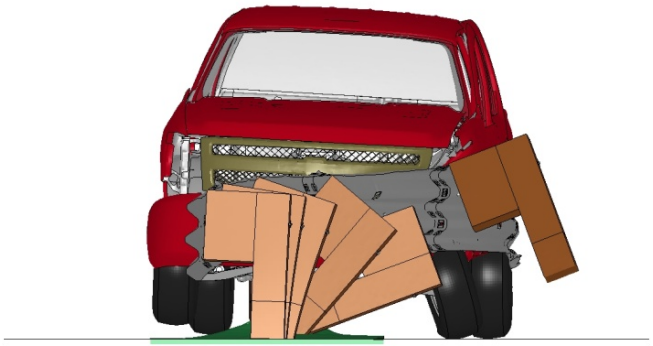
Florida Agricultural Mechanical University - Florida State University - TRACC



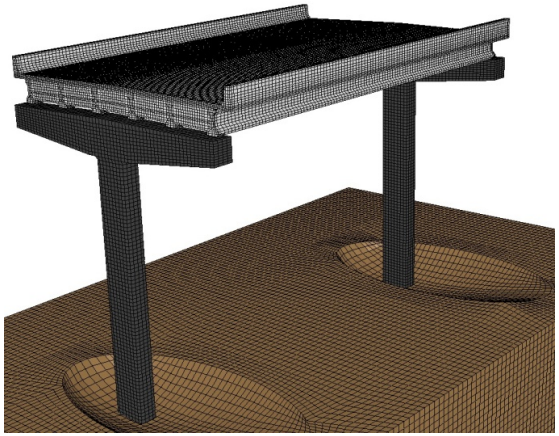
Federal Highway Administration/ Turner Fairbank Highway Research Center



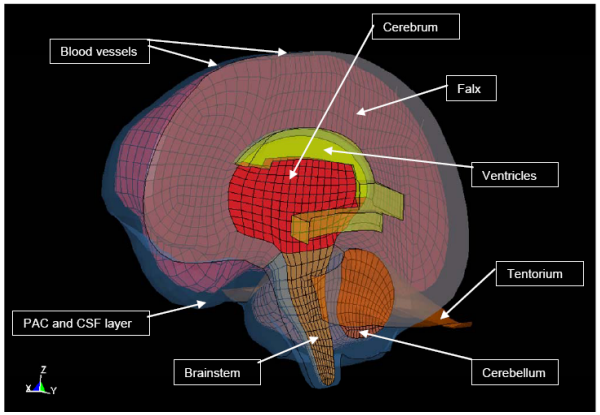
TRACC/NHTSA



Texas Transportation Institute



TRACC

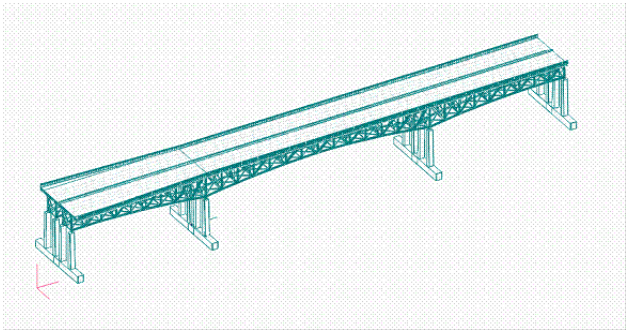


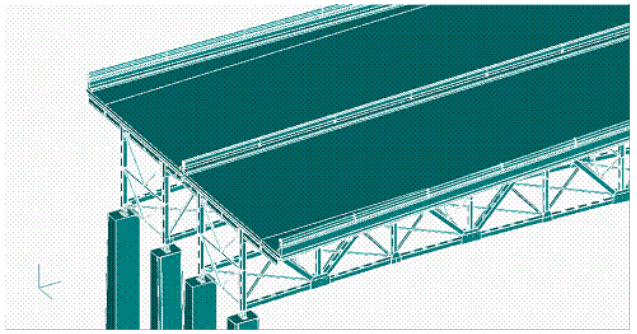
National Highway Traffic Safety Administration (NHTSA)

CSM Areas of Application

- Transportation Structures
  - Bridge Performance Assessment
  - Structural Health Monitoring
  - Pavements
  - Nondestructive Testing Validation (foundations, piers, etc.)
    - *Size, length, qualitative condition, subsurface material*
- Roadside Hardware Safety Performance
- Occupant Safety Assessment and Crash Biomechanics
- Vehicle Crashworthiness
- Transportation Materials
  - Asphalt, concrete, soil, steel

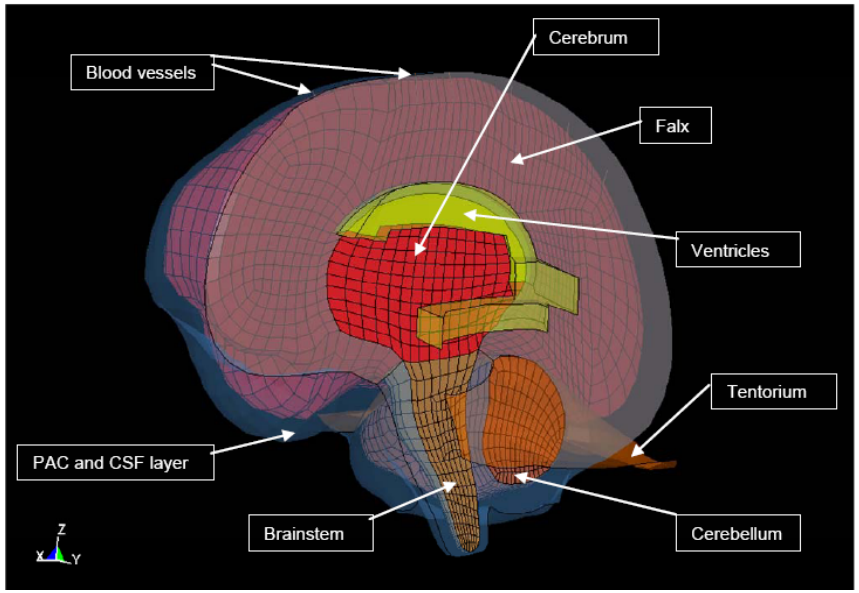
TFHRC Current Work: Patroon Island Bridge (NY)

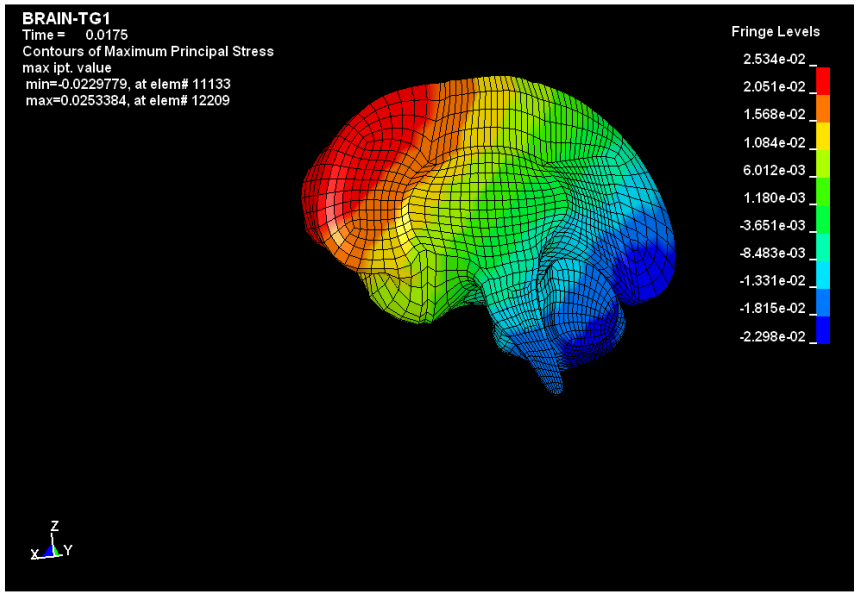




- In 2007, the collapse of the I-35 bridge in Minnesota greatly alarmed the DOT.
- A modeling and simulation effort was started by TFHRC to analyze other bridges of similar design, such as the Patroon Island Bridge, a major crossing of the Hudson River in Albany NY.

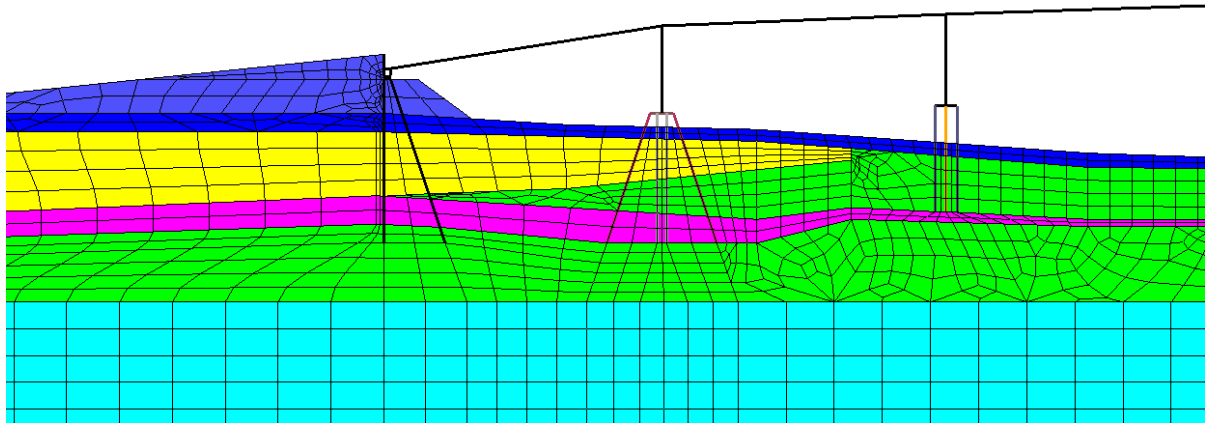
NHTSA Current Work: Traumatic Brain Injury





- Motor vehicle crashes remain one of the major causes of TBI in the US only second to falls.
- Finite element models have proven to be viable tools to better understand the biomechanics of TBI.
- Probabilistic analyses are being performed to identify important random variables and their effect on response distributions.
- Defining Characteristic: Small FE model, short compute time but hundreds of runs.

Structural Stability = Super-structure + Substructure + Foundation Soil



- To maintain a stable bridge structure, the superstructure, the substructure and the foundation soil must retain their load carrying capacities.
- Bridge pier scour can drastically reduce the load carrying capacity of the foundation soil by displacing the soil around the piers/piles.
- This may lead to failure of the substructure and the superstructure.

Computational Mechanics Software at TRACC

- LS-DYNA
  - License for 500 Cores (CPUs)
  - Multi-Physics Software (FE, SPH, MMALE)
- MADYMO / Node Frontier
  - 100 Token License
  - Design and Optimization of Occupant Safety Systems
- HyperMesh
  - 1 Core License
- User Developed Software

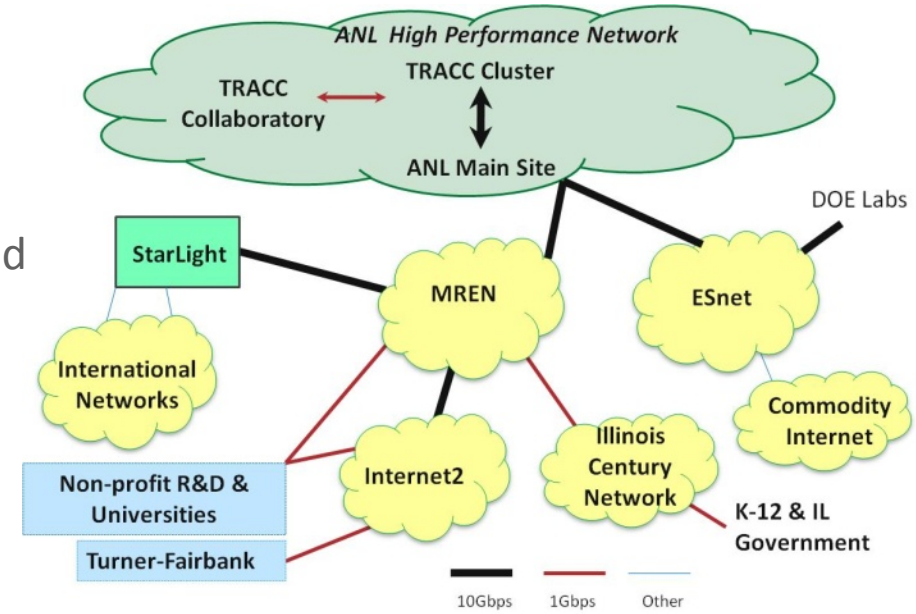
Computing, Networking, and Collaboratory Facilities

TRACC HPC Cluster

- 128 compute nodes/1024 cores
- 180TB of RAID storage
- Gigabit Ethernet network
- Low Latency InfiniBand network
- 160TB tape backup system

TRACC Network Connectivity

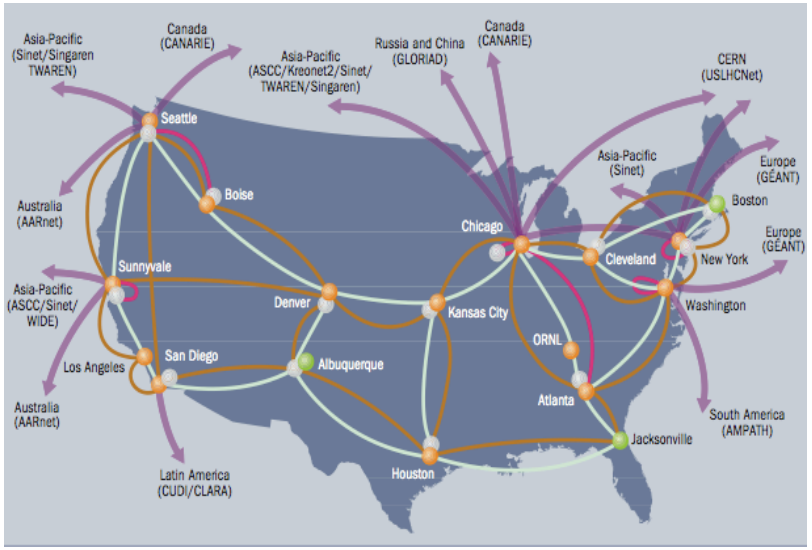
- TRACC is a part of the Argonne advanced fiber optic network
  - 1Gbps link to the DNTP NetPOP
  - 10Gbps link from the NetPOP to the Argonne main site



- TRACC, via the Argonne network, has network access to university, federal, state and local, and commercial transportation research centers world-wide via:
  - The Department of Energy network (ESnet)
  - The Metropolitan Research and Education Network (MREN)
  - The research and education network, Internet2
  - StarLight, an international network connection point

TRACC Collaboratory

- Outreach
- Training
- Collaboration
- Visualization
- Technology Enablement



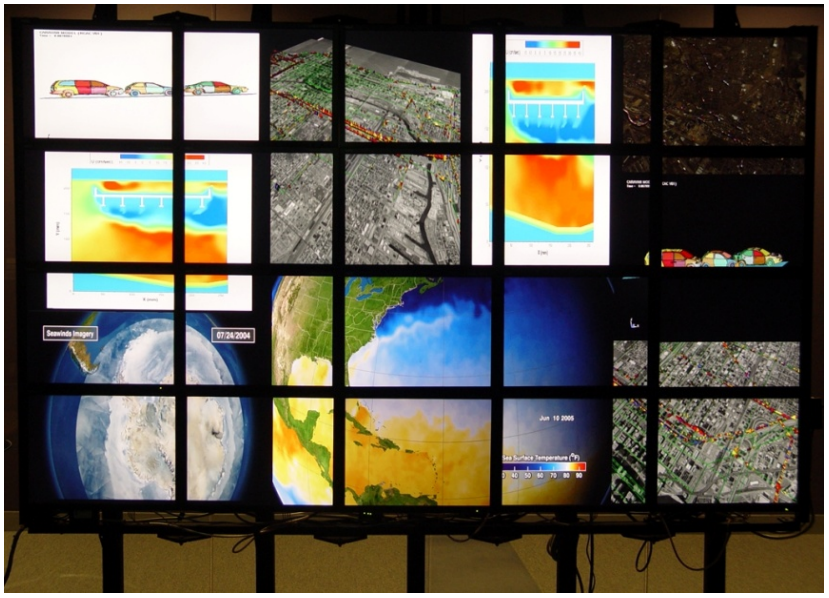
TRACC Collaboratory - Capabilities

Collaborative conferences, meetings and training with geographically distributed participants utilizing:

- Broadband access to global research and education networks
- Video Teleconference (vtc) systems
  - Web conferencing (Adobe Connect)
  - High-Definition (Polycom®) multi-point video and data sharing
- Demonstration and Training areas (two 15’ x 18’ rear-projection walls)
- Multiple vtc-enabled meeting spaces
- Advanced imaging and visualization

TRACC Collaboratory - Capabilities

- High-end Visualization Equipment
  - Passive stereo virtual reality display
  - High performance graphics cluster (20 panel LCD tile display; 8000 x 4800 pixels)
  - HD Stereo Theater projection system (1920 x 1080 pixel resolution)



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